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## ORIGINAL MEMOIRS.

### AVULSION OF THE SPINE OF THE TIBIA.

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I AM not aware whether any report has yet been published of a case in which the tibial spine has been sutured to the tibia after its avulsion; in fact, as far as I have been able to discover, there are only three instances of the injury on record: those of Dittel, of Poncet and of a patient admitted to University College Hospital, London, in 1873. In each of these cases the avulsion of the tibial spine was only discovered either after amputation or after the death of the patient.

I am therefore induced to publish, on account of the rarity of the condition, the following notes of a patient whose tibial spine was sutured to the tibia.

CASE I.—A. L., aged thirty-six years, was admitted to the Glasgow Royal Infirmary June 14, 1903, three days after having received a severe blow on the outer aspect of the left knee joint from the shaft of a cart. He was knocked down, and thinks that the knee was knocked inwards. He is a big, powerful man. The left knee greatly swelled from effusion into the joint cavity and there is a good deal of bruising of the superficial tissues. The only abnormal movement is in the way of abduction of the leg at the knee. This was so extreme that my house surgeon, Dr. A. B. Ross, reported the case to me as one of probable rupture of the

internal lateral ligament of the knee, and, after frequent examinations of the limb with a constant failure to elicit any antero-posterior movement or any abnormal rotation of the leg upon the thigh, I rather inclined to this idea of rupture of the internal lateral ligament. The question of rupture of both crucial ligaments was gone into, although I was not at that time aware that any operative treatment had ever been carried out for that injury; but there seemed to be no evidence in favor of this particular condition.

On June 26 I exposed the internal lateral ligament, but found it apparently quite intact. Before incising the tissues, and when the patient was under anaesthesia, renewed attempts at movement of the tibia on the femur failed to produce any abnormal antero-posterior movement.

The joint was then opened into, the blood and fluid in it washed out, and it was at once seen that the anterior crucial ligament still attached to its bone insertion had been torn off the tibia and taken the spine with it; with a little trouble this was sutured, and the wound closed. He made a good recovery and has been seen several times since. He was brought before the Glasgow Medical Chirurgical Society, November, 1903, and was last seen September 3, 1905, when he said he had perfect confidence in the strength of the knee; it troubles him only a little at times when coming down stairs. There was the very slightest degree of abduction permitted when the joint was fully extended. At the right knee joint no lateral movement whatever was permitted while fully extended.

CASE II.—At the time the forementioned patient came under my care, I had seen once or twice a gentleman who first consulted me in October, 1902, on account of a looseness and feeling of insecurity of his right knee joint. He had been injured at football the previous March and thought he had received the violence on the outer aspect of the limb. The knee had been greatly swelled directly after the injury and was in splints for three weeks. Since then he had never had any feeling of security in the limb. When I saw him there was no fluid in the joint, but there was a remarkable looseness, so that it seemed to be possible to abduct the tibia, while extended on the femur, through 25 degrees; it was not possible to displace the tibia forwards or backwards on the femur nor to produce any abnormal rotation at the

knee. The thigh muscles were much atrophied, the circumference of the right thigh being 35 and of the left thigh 38 cm.

In consequence of the absence of abnormal rotation, and, in fact, any abnormal displacement of the tibia upon the femur other than the abduction, I concluded the internal lateral ligament had been ruptured and that there was no evidence of injury to either of the crucial ligaments.

The patient would not then consent to operation; but in the following summer, as he found no improvement taking place, decided to have it, and, accordingly, on August 6, 1903, this was done. When he was fully anesthetized, on manipulating the joint it was found that the head of the tibia could be brought forwards on the femur for about 2 cm. (it had never been possible to do this previously), but no abnormal rotation could be brought about. In consequence of this abnormal displacement forwards it seemed very probable that the anterior crucial ligament was ruptured, but with so much abduction possible the original diagnosis of rupture of the internal lateral ligament as well, seemed to be justified in spite of the experience of the last case. The lateral ligament was therefore first exposed and found to be intact, at any rate as far as its superficial fibres were concerned. The joint was then opened and the anterior crucial ligament found torn from its femoral attachment. This was sutured to the tissues on the external condyle and the joint closed.

He made a good and uneventful recovery. I saw him on July 29, 1904, when he told me he had perfect confidence in the knee joint, that he hunted, ran to harriers and danced without any support to the joint. There was the very slightest abduction possible. The circumference of the thighs was, right 40, left 40.5 cm.

In August, 1905, he wrote saying he had given the joint a severe wrench while jumping and that it became much swelled, but I did not see him again until January, 1906, when he told me he was able to golf, run and dance again. The circumference of the thighs was now the same, 39.5 cm., and the amount of abduction possible at the extended knee was only of the very slightest degree, but there was a little.

Although avulsion of the tibial spine is a rare injury there have been a few cases of rupture of the crucial ligaments published during recent years, and some papers on the subject of

the mechanism of the injury have appeared. It may be worth while, therefore, to discuss the subject a little fully first of all from the point of view of the mechanism by which the injury occurs, and secondly from the diagnostic point of view.

The first patient to be operated upon was that of Battle. In this case both crucial ligaments were torn from the femur, and Robson recorded a case in which both ligaments were sutured after being torn "from their upper attachments."

Pagenstecher has recorded three cases operated on, in each of which one ligament only was ruptured: twice the anterior and once the posterior.

In consequence of their extraordinary strength, rupture of both crucial ligaments together can only occur as the result of very extreme violence and probably is associated always with gross injury to some of the other ligaments of the joint, and, more or less, complete dislocation, as was present in both Battle's and Robson's cases. I have had an opportunity of examining three knee joints which had been the seat of a recent dislocation of the tibia from the femur; both crucial ligaments had been torn in two of them, and in the third, the anterior crucial ligament was torn; but in all three there was extensive injury to some of the other (lateral or posterior) ligaments as well.

Regarding the rupture of one crucial ligament by itself, the matter is not quite clear, although many experiments have been carried out by Dittel, Pagenstecher and Honigschmied with the object of elucidating some points.

In Dittel's patient, with avulsion of the tibial spine, the injury took place apparently as the result of forcible separation of the tibia from the femur while the knee was in the flexed position; the patient died after the limb (the left) had been amputated (the nature of the injury was only discovered after dissection of the amputated limb), and on the cadaver, after prolonged attempts, Dittel succeeded in producing on the right knee the same injury by violence applied in the same manner.

Pagenstecher carried out a series of experiments and found that by flexing the leg forcibly over a large wooden bolster he

could rupture the anterior crucial ligament, and that he could also do so by blows applied from behind to the upper end of the tibia while the knee joint was flexed (both processes similar to the supposed method of the accident in Dittel's patient, *i.e.*, separation of the tibia from the femur). With blows applied to the upper end of the tibia from the front with the knee flexed he was able to produce rupture of the posterior-crucial ligament and often with tearing out of the "interecondyloid eminence." Pagenstecher could only rupture the anterior ligament from its femoral attachment, never from the tibial. Honigsehnied made a very large number of experiments on the cadaver regarding the effect of various extreme movements at the knee on the several ligaments of the articulation. While he was able to rupture one or other crucial ligament, and sometimes both, in a varying proportion of cases by movement in any direction, if carried out to excess, he seems to have ruptured the anterior crucial ligament most constantly by hyperflexion, tearing it from the femur, and the posterior crucial ligament most constantly by hyperextension and tearing it from the tibia. (In both Battle's and Robson's case the two crucials were torn from their femoral attachments.)

The question of rupture of these crucial ligaments has interested me a good deal, and I have made some observations on the dead subject regarding the anterior ligament, and the effect of its rupture upon the stability of the joint. I find that, provided the pelvis be fixed, it is not very difficult to rupture the anterior crucial ligament by a combined movement of flexion, abduction and internal rotation of the leg at the knee. I think it is mainly the internal rotation which is effective, and which is certainly more easily permitted when the joint is flexed than when it is extended; but once laceration of the fibres is started the abduction, no doubt, plays an important role, for, with a knee joint flexed and rotated inwards, if the anterior capsule be removed, and slight abduction be made, it can be seen that the anterior crucial ligament is tending to draw across the sharp internal margin of the external condyle; at any rate, in all my experiments the anterior crucial has only ruptured from its

femoral attachment, in this respect agreeing with Pagenstecher's results, and, I believe, that the draw across the internal border of the condyle by the abduction has some effect in leading to this result.

It appears to me to be quite possible that this combination of movements may have been the real mechanism of the injury in my two patients, certainly neither of them had the knee flexed over any object (in the manner of Dittel's and Pagenstecher's experiments), but both of them were of the opinion that they had been struck upon the outer aspect of the joint and that the knee had been knocked inwards, thus producing an abduction of the tibia on the femur; and it is conceivable that with such an injury the thigh and body of a patient might be swung round upon the fixed foot in such a manner as to cause an eversion of the thigh upon the tibia—equivalent to an inversion of the tibia on the femur. In further support of this idea, I may add that Pagenstecher states regarding his Case III that the knee "was knocked inwards" at the time of the accident; while his two other patients "fell upon the knee;" and of the first of these he writes that when the patient was first seen the limb was in a position of "slight valgus" (abduction). He also says of his patients Cases I and II that there was easy mobility to each side permitted at the knee, but regarding his patient Case III he states definitely that there was no lateral movement possible.

In the examination of both my own patients the most remarkable feature to me was the extraordinary degree of abduction that seemed to be permitted at the knee (there was no adduction) while the leg was apparently fully extended; it was so marked that the first diagnosis in each case was that of rupture of the internal lateral ligament.

It is not just easy to see why there should have been so free abduction as was present in these two patients, but it is probable that it is due to a combination of causes. Dr. Bruce Young has shown it is round the anterior crucial ligament, tightened up as it is by the extension of the joint, that the inversion of the femur takes place, as round a pivot, in the last move-

ment of locking the extended knee; and it may be that with this important ligament ruptured, and therefore unable to functionate, the inversion, and therefore the locking, is incomplete and, in consequence, a degree of abduction may be permitted which is not possible in an intact joint; for with an intact joint, as long as the tibia is extended upon the femur no abduction is possible at all, whereas if the knee be flexed to a very slight angle, and the locking thereby be undone, a certain degree of abduction becomes possible. Still, I do not believe that this explanation will account for all the abduction that was possible in my patients, for I have divided this ligament a great many times upon the cadaver, but have never been able to obtain the same degree of abnormal movement in this direction, as was present in the patients; but I observe if attempts to abduct the leg on the thigh are made when the anterior crucial ligament is divided that there is permitted a degree of internal rotation of the leg by which the swell of the calf of the leg comes to be more prominent at the outer aspect of the limb, so that at first the impression is produced that a greater degree of abduction has taken place than actually was the case; when completely extended there is only this rotation, although a slight degree of abduction does take place, if the knee be flexed.

There is, however, another factor to be considered; when I succeeded in rupturing the anterior crucial ligament on the cadaver I found on examining the ligaments of the joint that there was always a degree of tearing of the internal lateral ligament at its deep or articular aspect; it never was complete; it never involved, that is to say, the superficial fibres, and none of the other ligaments of the joint ever showed any degree of injury. With these short fibres of the internal lateral ligament ruptured it is not only possible but probable that a greater degree of abduction would be permitted than if they were intact.

Now in this connection it is worth recalling the statements of Pagenstecher regarding his patient Case I; it was of this patient that he wrote that the knee, after the injury, was in a "slight valgus position" and with "easy mobility to each side," and at the operation the posterior crucial ligament was

found torn, the anterior was intact: this is of interest, and, it seems to me, of considerable importance, for in a knee joint that is extended, the posterior crucial ligament ought not theoretically to have any effect whatever on the movements of the joint, for it is then in a state of relaxation. According to all anatomists the posterior crucial ligament is only tightened in the flexed position of the joint, and, unless the deep fibres of the internal lateral ligament were also torn, it is extremely difficult to understand how the leg could be either in a position of valgus or permit easy mobility to each side as long as the knee was extended.

Still with the injury as I have artificially produced it on the cadaver, *i.e.*, complete rupture of the anterior crucial along with rupture of the deep fibres of the internal lateral ligament and with the soft parts round the joint intact, I have never been able to get a degree of abduction at all comparable to that which was present in my patients.

Experiments regarding the rupture of the knee joint ligaments have also been carried out by von Hints, who states with reference to the crucial ligaments, that "after division of one lateral ligament he divided a crucial ligament and found he could obtain lateral movement of the knee in the hyperextended as well as the extended joint, and after division of both crucials along with one lateral ligament he could bend the knee almost to a right angle," but I have never been able to obtain a lateral bending to this extent of any of the knees examined. With the anterior crucial ligament alone divided through an incision exposing the interior of the joint, as for Kocher's method of resection and the soft parts otherwise intact, I find that if the knee joint be maintained extended there is no abduction permissible, whereas if flexed through about  $25^{\circ}$ – $30^{\circ}$  one can abduct the leg through about  $8^{\circ}$  at most. But if in addition the internal lateral ligament be divided and the knee flexed through  $25^{\circ}$  or  $30^{\circ}$  one can then abduct the leg through  $15^{\circ}$ ; but the abduction may appear to be rather more if one does not discount the internal rotation which, as already mentioned, tends to occur.



Through the kindness of Dr. T. H. Bryce I had an opportunity of examining, at Queen Margaret College, the ligaments of the knee joints of some dissecting-room subjects, with all the soft parts removed, and here, with both crucials along with one of the lateral ligaments divided, the greatest degree of lateral movement I could obtain was  $70^{\circ}$ , very much greater than I could get in any joint which had the surrounding soft parts intact, though considerably less than that obtained by von Hints.

The diagnosis of these injuries is not always easy. In the case of rupture of both crucial ligaments it is probable that antero-posterior movements of the tibia on the femur will always be abnormally free, and this should suggest the possibility of this injury, but in my two patients I never could produce this abnormal movement except in the second case, and then only when the patient was anesthetized, although it had been examined for on several occasions, as the question of rupture of one or other of the crucial ligaments had been discussed several times. One would, on theoretical grounds, expect that with rupture of the anterior crucial ligament alone the head of the tibia would be permitted to come forward in manipulation, and that with rupture of the posterior crucial the tibia could go backwards on the femur in the flexed position of the joint, in which position alone the posterior crucial is tense. Von Hints, however, states the direct opposite and quotes Dittel in support of his statement, but it is obviously altogether erroneous.

I am inclined to think that with an injury to a knee joint resulting in distention of the cavity with blood, provided no other lesion were obviously present, it might suggest injury to one or other of these crucial ligaments or to the tibial spine. If internal rotation of the extended leg were permitted at the knee, or if the head of the tibia could be brought forward on the femur, it would point to the anterior crucial or tibial spine as the seat of the injury, and perhaps an abnormal adduction would also. The one sign of rupture of the posterior crucial ligament alone should, so far as I can see, be the possibility of displacing the head of the tibia backwards while the knee joint

is in the flexed position. Abnormal abduction of the leg on the femur, I am inclined to attribute to rupture of, at any rate, the deep fibres of the internal lateral ligament.

Probably, however, in many instances the real nature of the injury will only be accurately determined by an exploratory operation, which is certainly called for in every case of instability of a knee resulting from accident, for an unstable, loose knee joint is useless for the support of a patient's weight, and in the few cases that have hitherto been treated the results of suturing the tibial spine or crucial ligaments have been very satisfactory.

Pagenstecher has suggested for this injury the term "internal distortion" of the knee, which appears to be altogether unnecessary, and is certainly not exact, whereas the terms "Avulsion of the tibial spine" and "Rupture of the crucial ligaments" label the nature of the injuries as precisely as can be desired; and they require to be kept distinct from one another, for one is a fracture of bone and the other is not.

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